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Weighing Device Achieves Zeptogram-level Sensitivity

By Ernie Tretkoff

The most sensitive mass measurements so far have been made using a new nanomechanical device, opening the door to weighing single molecules one at a time. The tiny new scale can weigh molecules with zeptogram (10^{-21}g) sensitivity, reported Michael Roukes of Caltech and his colleagues at the APS March Meeting in Los Angeles.

The researchers have used the device to detect in real time a cluster of about 30 xenon atoms, which weighs 7zg, about the same as a single protein molecule. With further improvements, the device could be used to distinguish different biomarkers of cancer, and could lead to better, cheaper, and faster instruments for molecular identification and proteomics, said Roukes.

The device is a nanomechanical resonator, consisting of a tiny

See ZEPTOGRAM on page 7

Congress Gets the Message

Photo Credit: Alan Chodos

Steve Pierson of the APS Washington office helps Taner Ozel of the University of Illinois at Urbana-Champaign to write to his Representative, as part of the Contact Congress campaign at the APS March meeting in Los Angeles. In 2002, when the Contact Congress campaign was launched, only 580 March Meeting attendees wrote. This year, Ozel was one of 1,400 participants.

"It's essential for us to show members of Congress that their constituents care about science," said APS Senior Policy Fellow Dave Cooper, who spearheaded this year's effort for the Washington office, "and the participants in the March Meeting campaign have helped us toward that goal in big way. We keep track of how many messages go to each member of Congress and use the numbers to get the attention of congressional staff."

Last year's email-writing campaigns helped galvanize support of 55 senators who urged increasing the budget of the DOE Office of Science, which was slated for a cut. Ultimately, Congress boosted DOE science programs by 4.3%.

Anyone interested in the letter-writing campaign can still participate by following the "Write Congress" link at www.aps.org/public_affairs.

APS Joins STEM Community in Call for Support of Science Education Programs

The Administration's FY 2006 budget request would slash funding for science education programs at NSF and restrict the availability of funds for the Math and Science Partnership (MSP) program at the Department of Education. The APS has joined with several other scientific and educational organizations in the Science, Technology, Engineering and Mathematics (STEM) Education coalition by co-signing a letter to congressional appropriators in support of the NSF programs.

The other signatories include the American Association of Physicists in Medicine, the American Association of Physics Teachers, the American Astronomical Society, the American Geophysical Union, the American Institute of Physics, and the Optical Society of America. Many of these organizations also signed a letter to appropriators in support of the DOE's MSP program. And several Members of Congress have circulated "Dear Colleague" letters on both topics, seeking additional Members' signatures on letters that will be sent to the relevant appropriators.

The Administration has proposed $737.0 million for NSF's EHR Directorate, a cut of 12.4% from the FY 2005 level of $841.4 million, which itself was 11% lower than FY 2004 funding of $944.1 million. Many programs and divisions–including the NSF Math and Science Partnerships; Elementary, Secondary and Informal Education; Undergraduate Education; and Research, Evaluation and Communication–would receive cuts ranging from 12% to 43%. Under the budget request, several of these accounts would make no new awards in FY 2006.

The Coalition's letter on NSF science education programs was sent to key members of the House Science, State, Justice and Commerce Appropriations Subcommittee and of the Senate Commerce,

See STEM on page 4

APS Seeks Assistance for Tsunami Victims

APS is seeking donations to help victims of the tsunami that hit Southeast Asia last December. The donations will go to a fund to assist 24 students at Ruhuna University in southern Sri Lanka.

"After the devastation from the tsunami that hit Southeast Asia last December, the American Physical Society is reaching out to the physics community in the affected areas," said Amy Flatten, APS Director of International Affairs.

APS President Marvin Cohen wrote to leaders from the physical societies and universities in those countries hit by the disaster, pledging APS assistance however possible.

Shortly after sending the letter, the APS received a call for help from P. Samarasekara, head of the physics department of the University of Ruhuna, located in the deep southern part of Sri Lanka. Samarasekara explained that he had been informed of Cohen's letter, which was disseminated throughout the Sri Lankan physics community.

Samarasekara wrote to Cohen regarding a fund that has been set up by the Ruhuna University Science Teachers

See TSUNAMI on page 7

March Meeting Teachers' Day

Photo Credit: Edward Lee

Lily Min (l) and Su Lin Haggerty, two physics teachers in the LA area, disassemble a small DC motor in a workshop at the APS High School Physics Teachers' Day. This Teachers' Day was partially supported by Lucent Technologies and Applied Materials.

Committee Picks First Five Historic Sites

The APS Historic Sites Committee has announced its first five picks for important physics history sites in the United States.

Following an earlier initiative of the Forum on History of Physics (see *APS News*, December 2002), the APS Executive Board appointed the committee last fall. It consists of John Rigden (Washington University, St. Louis), who serves as Chair, and Mildred Dresselhaus (MIT), Sidney Drell (SLAC), Gerald Holton (Harvard), and Gordon Baym (U.of Illinois, Urbana-Champaign). Spencer Weart of the American Institute of Physic's History Center, and Alan Chodos of APS act as committee advisors.

The goal of the historic sites initiative is described in a memo to the Executive Board by Rigden on behalf of the committee: "The purpose of the Historic Sites initiative is to raise public awareness of physics. We believe that unexpected encounters with an attractive plaque that identifies an important and interesting event in the history of physics will be an effective way of getting physics before the general public. Also, we recognize the initiative will benefit physicists by increasing their own awareness of important past scientific advances, hence of their membership in the historic evolution of their profession."

The committee decided, for its first selections, to take a chronological approach and concentrate on older sites with incontrovertible significance. The first five sites were specifically chosen in 2005 as part of the celebration of the World Year of Physics. They are:

–Case Western Reserve University and the Michelson-Morley Experiment

–Johns Hopkins University and Henry Rowland

–Philadelphia and Ben Franklin

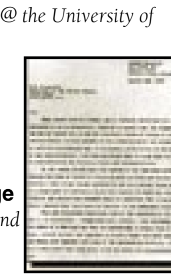
–Washington University and Arthur Compton

–Yale University and J. Willard Gibbs.

On sites where plaques already exist, the APS will place a small plaque identifying the

See HISTORIC SITES on page 4

Highlights



Members in the Media

"It's to remind people that our picture of the physical universe changes, that how we look at the physical universe profoundly affects our life and that this is fun stuff to think about,"
–Jim Isenberg, University of Oregon, on the purpose of the World Year of Physics, The Register-Guard, (Eugene, Oregon) March 13, 2005

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"The Strip is interesting. There is a lot to look at. There is a lot going on. Every time you turn a corner, there is something new to look at. All of that will be very positive."
–George Neil, JLab, on running the Las Vegas Marathon on the Strip, Las Vegas Sun, March 31,2005

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"This is a mathematical mapping, and these are not real black holes."
–William A. Zajc, Columbia University, on the black hole-like things possibly produced by RHIC, The New York Times, March 29, 2005

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"There are no other plans to reach the edge of the solar system. Now we're getting all this new information, and here comes NASA saying, 'We want to pull the plug."
–Stamatios Krimigis, Johns Hopkins University Applied Physics Laboratory, on the possibility of NASA ending the Voyager mission to save money, The Washington Post, April 4, 2005

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"Voyager is the same [as Hubble]–one of the classic American contributions to space. Voyager's photographs are all over astronomy textbooks."
–Louis J. Lanzerotti, New Jersey Institute of Technology, The Washington Post, April 4, 2005

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"These long wavelength swells grow with time and give an extra expansion to the universe."
–Rocky Kolb, Fermilab, on his suggestion that very long wavelength ripples in space-time, rather than dark energy, can explain the accelerating expansion of the universe, Reuters, March 22, 2005

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"Undamaged units in a [nanobot] swarm will join together, allowing it to tolerate extensive damage and still carry on its mission."
–Steven Curtis, NASA, Christian Science Monitor, April 7, 2005

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"We actually taught (the old book) to a bunch of students who came to the cyclotron, and we realized how bad it was."
–Howard Matis,Lawrence Berkeley National Laboratory, on revising the Boy Scout nuclear science merit badge program, Contra Costa Times April 7, 2005

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"When I was at Caltech, Feynman was God, pretty much."
–Doug Osheroff, Stanford University, on Richard Feynman, The New York Times, April 7, 2005

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"He had a half-hidden strength of real decency and kindness. He had the knack for making science feel important and exciting, and he inspired very large numbers of people to be excited about physics."
–Virginia Trimble, University of California, Irvine, on Richard Feynman, The New York Times, April 7, 2005

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"I have never seen good data on what is a fair balance between textbook companies being able to make a fair profit, and the students having a reasonable level of cost. I think the students have reasonable questions. What I hope to gain is some useful dialogue."
–Michael Dennin, University of California at Irvine, on textbook prices, the Boston Globe, April 8, 2005

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"I wanted to get across the idea that integrated circuits were a way to make electronics cheap. I blindly extrapolated for 10 years continuing to double every year, from 60 components to 60,000, not thinking that it was going to be especially accurate but just trying to get the idea across that it would be significantly more complex and a lot cheaper."
–Gordon Moore, on Moore's law, San Jose Mercury News, April 7, 2005

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Building a Better Fuel Cell Using Microfluidics

By Ernie Tretkoff

A novel microfluidic fuel cell uses laminar flow to operate without a solid membrane separating fuel and oxidant, making possible efficient alkaline fuel cells that could provide cheap and effective power for small electronic devices. Paul Kenis of the University of Illinois at Urbana-Champaign described the new design at the APS March Meeting in Los Angeles.

See FUEL CELL on page 7

This Month in Physics History

Einstein and General Relativity

Einstein's theory of special relativity ensured his place among the greatest physicists of all time, but Einstein himself wasn't satisfied. He knew there was a piece missing, and he spent the next decade hammering out the details of a more general theory of relativity that could incorporate acceleration, which was ignored by special relativity.

Even Einstein's close friend, Max Planck, felt that his younger colleague had taken on a well-nigh impossible task. "As an older friend, I must advise you against it, for in the first place you will not succeed; and even if you succeed, no one will believe you," Planck wrote. But Einstein persevered. And he found the key to general relativity in an elevator analogy in 1907. He realized that someone riding in an elevator couldn't tell the difference between gravity and acceleration, and he elevated this insight to a general principle, which he called the Principle of Equivalence: the laws of nature in an accelerating frame were equivalent to the laws in a gravitational field.

Furthermore, gravitational "force" could be explained by pure geometry. In the seventeenth century, Isaac Newton had considered gravity to be an instantaneous interaction between two separate bodies, and that view had persisted during the intervening centuries. Instead, Einstein chose to envision gravity as arising from the geometric curvature of space-time caused by massive celestial objects. But he initially lacked the mathematical formalism he needed to express his physical principle. He struggled with the problem for three long years, writing to his close friend, Marcel Grossmann, "Grossmann, you must help me or else I'll go crazy."

Grossmann came through for his friend. He alerted Einstein to the work of the 19th century German mathematician, Georg Friedrich Bernhard Riemann, who, in a famous 1854 lecture, had developed a generalization of

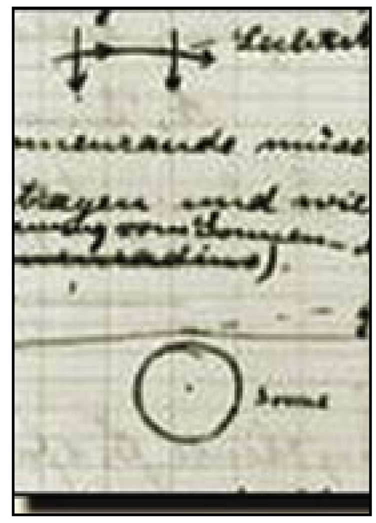

Photo Credit: American Institute of Physics

A 1914 sketch by Einstein on how the Sun's mass might cause light to bend.

Photo Credit: American Institute of Physics

A 1919 photo of the solar eclipse that confirmed Einstein's predictions.

Euclidean geometry that now bears the name Riemannian geometry. Central to the discussion was the metric tensor, which, in four dimensions, has ten independent components and which describes the coordinate-invariant distance between two nearby points. From the metric tensor one can compute the local curvature and any other quantities of geometrical interest.

Treating the metric tensor as a dynamical field analogous to the electromagnetic potential in Maxwell's equations, Einstein found he could incorporate the entire body of Riemann's work into a field theory of gravity. This turned into general relativity, which Nobel laureate Subrahmanyan Chandrasekhar once called "the most beautiful theory that ever was." Einstein completed the formulation of the theory in late 1915 and early 1916.

Every new theory must have its predictions experimentally tested and verified. As Einstein showed, general relativity could account for a hitherto unexplained piece of the precession of the perihelion of the planet Mercury. In addition, as Einstein had noted years earlier, it is a direct consequence of the principle of equivalence that light emanating from a massive body should be redshifted. This effect was first observed as a terrestrial effect many years later, in 1960, by Pound and Rebka.

Finally, according to general relativity, when a ray of light passes near a massive body, the ray should be bent. For example, starlight passing near the sun should be slightly deflected by gravity. This deflection could be measured when the sun's own light was blocked during an eclipse. Einstein predicted a specific amount of deflection, and the prediction spurred British astronomers to try to observe a total eclipse in May 1919. Feverish preparations began as World War I ended. Two expeditions, one to an island off West Africa and the other to Brazil, succeeded in photographing stars near the eclipsed sun. The starlight had been deflected just as Einstein had predicted.

Announcement of the eclipse results caused a sensation, and not only among scientists. It brought home to the public a transformation of physics, by Einstein and others, that was overturning established views of time, space, matter, and energy. Einstein became the world's symbol of the new physics.

It is an interesting footnote to this story that, if one uses only special relativity, one obtains a deflection that is half the full amount predicted by general relativity. Einstein had suggested this experiment in 1913, but with the wrong numerical prediction. If war had not intervened, delaying the observation until 1919, the agreement between theory and observation would have been much less dramatic. Timing and luck cannot be discounted as factors in shaping the history of physics.

Sources:

AIP exhibit: http://www.aip.org/history/einstein/

Kaku, Michio. *Hyperspace.*

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Fluid Flow Studies Help Understanding of Aneurysms

By Ernie Tretkoff

Studies of fluids can lead to better understanding of aortic aneurysms, researchers reported at the APS March Meeting.

Anne-Virginie Salsac of the University of California, San Diego, described how changes in blood flow patterns contribute to the growth and rupture of abdominal aortic aneurysms.

Abdominal aortic aneurysms are abnormal dilations of the major blood vessel that supplies blood to the lower part of the body. They affect about 3% of the population over age 50. These bulges in the arterial wall often have no symptoms until they rupture, at which point as many as 80% of them are fatal. Men are more likely to be affected by this condition than women, and smoking, high blood pressure, and insufficient exercise are also risk factors. This is a major health issue, said Salsac, but much remains unknown about the problem.

Currently there is no technique to predict the expansion rate of abdominal aortic aneurysms or the critical size when they rupture, said Salsac.

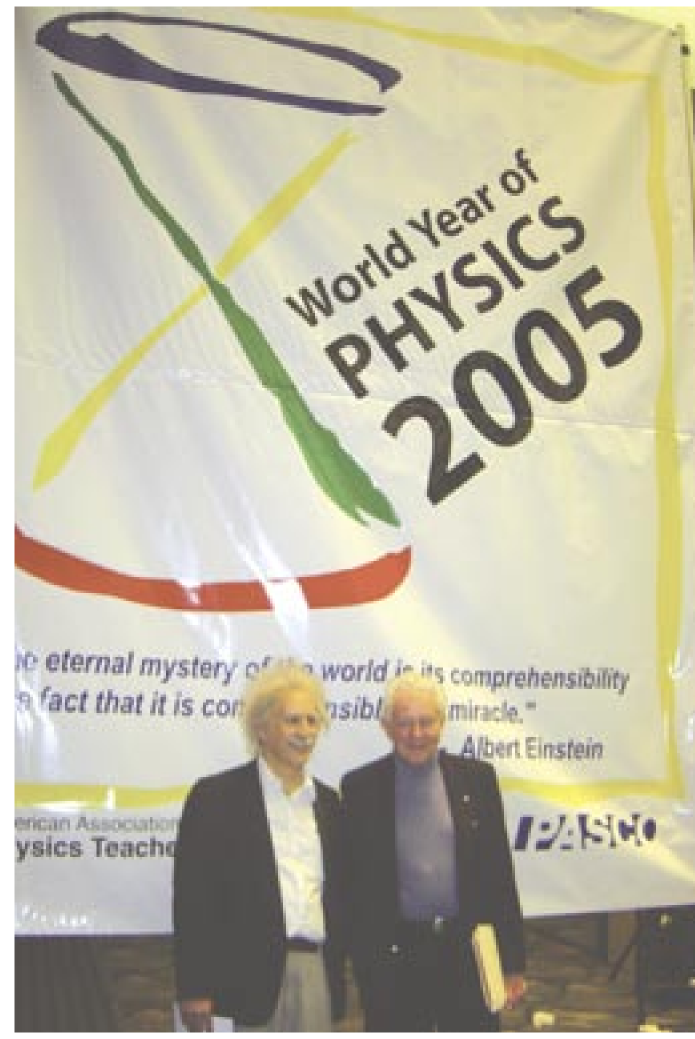
Studies have shown that the mechanical forces exerted by the blood flow on the arterial wall play an important role in controlling the biological processes in the arterial wall cells, said Salsac. "Blood shear force controls the cell function and thus the structure and integrity of the arterial wall," she said.

But no one had actually measured these forces before. Salsac made the first measurement of the spatial and temporal distribution of forces along the wall of an abdominal aortic aneurysm. She measured these forces in a model of an aneurysms, while systematically changing the size and shape of the aneurysm.

Salsac found that because of the aneurysm's bulged shape, the fluid flow separates from the arterial wall, and a large vortex develops. The vortex ring then hits the blood vessel downstream where the aneurysm narrows. This creates a region of very high stress on the arterial wall in the downstream part of the part of the bulge, while leaving regions of low force on the upstream artery wall.

The abnormally low shear stresses upsteam in the dilated region actually lead to endothelial cell dysfunction, weakening the arterial wall, and possibly causing the aneurism to grow, reported Salsac.

A Banner Occasion



Jessica Clark

Two Nobel laureates, Albert Einstein (left, as portrayed by Marc Spiegel) and Leon Lederman (right, playing himself) stand in front of a gigantic World Year of Physics banner at the "Just Physics" reception for physics teachers at the meeting of the National Science Teachers Association in Dallas in early April. The reception was sponsored by PASCO, as well as by the American Association of Physics Teachers and the World Year of Physics 2005.

New Digitizer Captures Ultra-Quick Waveforms

For the first time, researchers at the University of California, Los Angeles, have succeeded in capturing and digitizing electrical signals at the rate of 1 trillion times per second, a discovery that may allow physicists to peer into the fundamental building blocks of nature and eventually help scientists develop defenses against high-powered microwave weapons attacks. The breakthrough was announced at the APS March Meeting in Los Angeles.

UCLA professor Bahram Jalali and graduate researcher Yan Han developed the digitizer, which captures lightning-quick waveforms 40 times faster than the best commercially available digitizers. Most researchers in recent years have focused on speeding up the digitizer itself; Jalali and Han chose to slow down the electrical waveforms using a novel optical time-dilation processor, and then digitize the pulses at picosecond intervals.

Measurement of electrical waveforms is needed in virtually every field of engineering and science. Among the potential applications being studied is the development of defenses against the microwave "e-bomb," in which a burst of electromagnetic energy is created and directed at an electronics system, burning it out. The UCLA researchers also showed that the resulting time elasticity can be used to perform time compression and time reversal, capabilities with potential application in advanced radar systems.

The UCLA approach could also benefit particle physics, since the technique would allow physicists to capture the smashing of particles, and by analyzing that instant, peer into the most fundamental building blocks of nature on the smallest scale. RadiaBeam Technologies LLC in Los Angeles has already begun licensing negotiations with ULCA for the patents that led to the breakthrough. The plan is to commercialize the technology into a laboratory tool for high-energy physics.

Members of Congress Speak Out in Support of Science

With Congressional attention focusing increasingly on the pending FY 2006 appropriations bills, there were numerous statements on the Bush Administration's FY 2006 budget request and several House Science Committee hearings in March, most notably from Senator Lamar Alexander (R-TN) and Rep. Vernon Ehlers (R-MI).

Alexander has been a strong supporter of federal S&T programs. In a Senate Budget Committee report accompanying the Senate Budget Resolution, S. Con. Res. 18, Alexander was responsible for the following language: "The budget resolution recognizes the importance of the research and education initiatives of the DOE's Office of Science and the NSF to the nation's economic future and our position as the world's leader in technology innovation. Investment in the physical sciences, life sciences, engineering, mathematics, and computing is critical to our national security, energy security, as well as development of the next generation of America's scientists and engineers."

The report pointed out that other countries are investing heavily in research that produces talented, highly-educated workers and cutting-edge companies. China graduates almost four times as many engineers as the US India is pouring money into technology parks to lure back native talent and produce world-class companies. South Korea graduates nearly the same number of engineers as the US though it has $1/6^{th}$ the population and $1/20^{th}$ the GDP. The European Union is poised to graduate four times as many PhD's as the US over the next five years. "Clearly, the statistics point to an emerging crisis in US competitiveness like never before and sustained investment in science and technology at the DOE's Office of Science and the NSF must be at the core of America's strategy to compete," the report said.

Ehlers is the chairman of the House Subcommittee on Environment, Technology and Standards of the House Committee on Science. In this role, he recently appeared before the newly established House Appropriations Subcommittee on Science, State, Justice, and Commerce and Related Agencies, chaired by Rep. Frank Wolf (R-VA). (This subcommittee does not have jurisdiction over the DOE Office of Science.) Ehlers testified in support of the National Institute of Standards and Technology, NIST and the National Oceanic and Atmospheric Administration at this March 15 hearing.

While recognizing the need to balance fiscal priorities, "We must not overlook the fact that scientific research and development forms the foundation of increased innovation, economic vitality, and national security for our nation," Ehlers said, citing the National Institute of Standards and Technology as one of the nation's most critical science organizations. "Almost every Federal agency and US industry sector uses the standards, measurements, and certification services that NIST labs provide. The future of many cutting-edge technologies depends on the research and technical expertise of NIST's laboratories." He asked Congress to provide the President's requested funding of $426 million in FY 2006 for the Scientific and Technical Research Services account at NIST.

Ehlers also spoke out in support of the NSF. In 2002 Congress authorized a doubling of the agency's science research budget. However, said Ehlers, "We have not stayed the course on this proposed doubling path," and asked Congress to fund the NSF in FY 2006 at $6.1 billion, still $2.4 billion below the authorized level for FY 2006. In 2005, the budget for NSF was reduced, particularly in the area of education programs. Last year, Congress only appropriated $5.47 billion for the NSF, well below the $5.75 billion requested by the administration.

–Excerpted from FYI, the American Institute of Physics Bulletin of Science Policy News (http://aip.org/fyi)

San Diego Hosts Fellows' Reception

Photo Credit: Darlene Logan

A reception for APS Fellows in the San Diego area took place on March 8 on the campus of UC San Diego. In the photo at left, local host M. Brian Maple of UCSD chats with Vincent Chan and Ronald Waltz of General Atomics. In the photo at right, Daniel Dubin of UCSD (left) and Adrienne Dubin are shown with colleague Kim Griest of UCSD. The Fellows enjoyed refreshments and conversation, and heard brief presentations on APS activities from APS President Marvin Cohen, Executive Officer Judy Franz, Director of Education & Outreach Ted Hodapp, and Director of Public Affairs Michael S. Lubell.

LETTERS

Use the Space Station to Save Hubble

I read with interest Ernie Tretkoff's article about the controversy over the fate of the Hubble Telescope. Two facts stated in the article struck me as providing a possible solution to the problem of keeping the Hubble alive, as follows:

The President's budget allocates $93 million for the Hubble Space Telescope, but $75 million of that amount would go towards developing a robot to steer the telescope safely out of its orbit . . .

The President's budget does include space shuttle flights to the International Space Station.

Why not spend the $75 million to develop a robot to steer the telescope safely to the International Space Station, send up a repair team to fix it there, and use the robot to put it back in orbit? As I recall, one of the original justifications for the Space Station was exactly this kind of mission. What a triumph this could be! Save the Hubble telescope and demonstrate the value of the Space Station, all with minimum budget impact. Why not?

Alexander J. Glass
Berkeley, CA

Pertinent References Omitted

The letter from Roy Weinstein in your March 2005 issue, regarding the appearance of a Lorentz-contracted object, would have been more complete if it had included one or more of the pertinent references to this discovery:

James Terrell: The Clock Paradox, Los Alamos Document LA-DC-2842, April 1957 (submitted to *Nature*, but not published).

James Terrell: Invisibility of the Lorentz Contraction, Bull APS 4, 294 (April 30, 1959).

James Terrell: Invisibility of the Lorentz Contraction, Phys Rev 116, 1041–1045 (Nov 15, 1959).

V. F. Weisskopf: The Visual Appearance of Rapidly Moving Objects, Physics Today, Vol 13, No. 9, 24–27 (Sept. 1960).

James Terrell: The Terrell Effect: Invisibility of the Lorentz Contraction; Editorial Note and Letter to the Editor, *American Journal of Physics* 57, 9-10 (Jan.1989.)

R. Penrose: The Apparent Shape of a Relativistically Moving Sphere, Proc. Camb. Phil. Soc. 55, 137–139 (1959).

This (originally) surprising result is evidently still not well-enough known, and should not be allowed to vanish into obscurity and oblivion. It has led to a considerable number of subsequent papers.

James Terrell
Los Alamos, NM

Editor's Note:

After receiving the letter from James Terrell, we received a further communication from Roy Weinstein, pointing out that his original letter contained a reference to Terrell's work, which was omitted in the version we published. Since APS News is not a scholarly publication, we often (though not always) edit out references in footnotes. In this case, the effect was to slight Terrell's contibution and also to make Weinstein appear uncharitable, neither of which we intended. We apologize to both authors.

STEM *from page 1*

Justice, and Science Appropriations Subcommittee. It calls on Members of Congress to "increase spending for [NSF] to a level that would permit $200 million in funding for the NSF Math and Science Partnership (MSP) program, and restoration of funding for the NSF Education and Human Resources Directorate to FY2004 levels."

The letter also expressed support for other key programs in the EHR directorate, such as Instructional Materials Development, the Teacher Professional Continuum, and the Centers for Learning and Teaching.

"These programs are unique in their capacity to move promising ideas from research to practice, to develop new and improved materials and assessments, to explore new uses of technology to enhance K-12 instruction, and to create better teacher training techniques," it said.

While recommending a 51.0% increase (to $269.0 million) for the Education Department's MSP program in FY 2006, the Administration also proposes to fence off $120.0 million of that funding for a new grant program for secondary math that would redirect funding away from the state-based MSP program. The Administration proposed this same set-aside last year, but Congress did not approve it. The Coalition sent another letter to key Labor-HHS-Education appropriators in both chambers. This letter supports the requested funding level but opposes the $120.0 million set-aside.

The full text of the letters can be found at http://www.aip.org/gov/

HISTORIC SITES *from page 1*

site as being in the APS registry of historic physics sites. At sites where there is no existing commemoration, a larger plaque will describe in more detail the reason why the site has historical significance.

Later this year, the APS will launch a historic sites web page that will serve two purposes: first, to house the online registry of the sites already chosen, and second, to provide a mechanism for members of the physics community to nominate sites that they wish the committee to consider.

Forum on Education Leads Endowment Drive For New APS Excellence in Education Award

Fundraising is underway for the new Excellence in Physics Education Award that has been approved by the APS Council. The Forum on Education is spearheading the fundraising campaign.

The APS Excellence in Education Award is unique in that it seeks to recognize a group (such as, for example, members of a university physics department), rather than a single person. The criteria for the Award state that the Excellence in Physics Education Award will recognize and honor a team or group of individuals (such as a collaboration), or, exceptionally, a single individual, who has exhibited a sustained commitment to excellence in physics education. Such a commitment may be evidenced by, but not restricted to, such accomplishments as:

- Outreach programs
- A specific program or project that has had a major ongoing influence on physics education at the national level
- Outstanding teacher enhancement or teacher preparation programs over a number of years
- Long-lasting professional service related to physics education that has had a demonstrated positive impact.

The fundraising campaign has already raised $30,000 of its $100,000 goal. The Forum on Education will match up to $30,000 in contributions from APS members so such contributions are doubly valuable.

Any contribution over $100 can be designated to honor a teacher or mentor who has been influential in the donor's professional training. The APS will send a letter to the honoree or the honoree's family to inform them of the gift.

If the campaign receives strong support this year, the Award can become fully endowed in 2005, with the first award then given in 2006. Once the goal is met, an Excellence in Physics Education Award of $5,000 will be given annually.

Additional information including downloadable and electronic pledge forms are available on the Forum's web page:

http://www.aps.org/units/fed/

INSIDE THE BELTWAY:
Washington Analysis and Opinion

Michael S. Lubell

Caveat Emptor

by Michael S. Lubell, APS Director of Public Affairs

Politics is ten % policy and ninety % marketing. This year, the White House seems to be taking its cues from a well tested packaging strategy. If you're selling corn flakes, and you want to increase your profits without hiking the price, make the box larger and downsize the contents. Caveat emptor!

Whether it's Social Security or science budgets, the Administration's marketing approach this year has been the same. Let's consider Social Security first. In his 60-day selling blitz, President Bush touted personal investment accounts, which he said would generate far higher returns than the federal treasury notes in which Social Security invests. He's right of course, and the odds are that you won't even have to make your investments over a forty year period to have a good shot at coming out well ahead.

In fact, Gary Burtless, who holds the John C. and Nancy D. Whitehead Chair of Economic Studies at the Brookings Institution, has calculated that for more than a century, beginning in 1871, the historical 15-year average return on stocks has been 6.3%. Furthermore, he noted in Congressional testimony some years ago that "over long periods of time, investments in the US stock market have outperformed all other types of domestic US financial investments, including Treasury bills, long-term Treasury bonds, and highly rated corporate bonds."

But now read the contents label on the President's package. If you opt to invest some of your Social Security tax in individual accounts, you will have to return part of your gain to the government. How much? According to the White House plan, inflation plus 3%. If inflation, itself, runs at about 3%, which is the Bureau of Labor Statistics' common assumption, you would fork over 6% of your profit. Add a 1% management fee and you'd be out of pocket 7%. Net-net, you would suffer a 0.7% loss. Caveat emptor!

It's much the same with the packaging of the science budget for Fiscal Year 2006 that the Administration released on February 7. In commenting on the White House R&D budget a week later, John H. Marburger, III, President Bush's Science Advisor, asserted that the Administration's plan "maintains and selectively strengthens" scientific research. While admitting to having to make "hard decisions," he pointed out that the National Science Foundation's budget would rise by 2.4% to $5.6 billion, at the same time that most other domestic discretionary programs would be declining.

But read the contents label. It's true that Research and Related Activities would receive an additional $113 million, a gain of 2.7%. But of that, $48 million is attributable to a transfer of funds from the Coast Guard to operate its two icebreakers for the NSF's Polar Program. According to analysts familiar with the issue, however, operating the icebreakers would actually cost NSF an estimated $70 million for the coming fiscal year, resulting in a net increase of only $43 million for Research, or a just under 1%. But even this gain could be illusory, since it doesn't include any down-payment on the estimated $500 million that will be needed in the next few years to repair or replace the two rusting vessels. And as for Science Education, NSF would have its role reduced bymore than 12%. Caveat emptor!

The Administration also offered up the core programs (STRS) of the National Institutes of Standards and Technology (NIST)–which have produced three Nobel prizes in the last eight years–as an example of its commitment to research. According to the White House Budget Request package, the Commerce Department's Technology Administration would commit an additional $47 million to Research in STRS, an increase of 12.7%, based upon the AAAS R&D budget analysis.

Looks stellar, but read the contents label. As advertised, the Administration would also proceed with plans to terminate the NIST Advanced Technology Program. But the proposed budget provides no money for the close-out costs, estimated to run about $50 million. Assuming NIST bears the costs, the $47 million gain for STRS becomes a $3 million loss. Caveat emptor!

It's much the same story with other federal agencies, where the total R&D number might go up, but research funding would go down. The notable exception is the Department of Energy, where no amount of clever packaging can mask the dramatic cuts to science, now estimated to run in excess of 4.5%. At least give Ray Orbach, the Director of the DOE Office of Science, and Sam Bodman, the new Secretary of Energy, credit for truth in marketing. This year, they're about the only ones who deserve it.

Statistical Physics Can Help Build a Better Flu Vaccine

A new way to study the effectiveness of flu vaccines is to use the tools of statistical physics, according to Rice University's Michael Deem. Deem has taken the random energy or spin glass models originally used to describe nuclear cross-sections and applied them to epidemiology. At the APS March Meeting, he described how this method could provide a better prediction of a particular flu vaccine's efficacy in a given year. A higher efficacy means that fewer vaccinated individuals get the flu relative to unvaccinated individuals.

Influenza epidemics are a major concern that affects a large majority of the world's population, killing between 250,000-500,000 people every year; the US mortality rate alone is more than 40,000 per year, with estimated annual costs in lost work days and health care topping $10 billion in the US.

Early each year, the World Health Organization in Geneva recommends which three strains to include in the next winter's flu vaccine for both hemispheres. The three chosen strains are then grown in chicken eggs before being tested for safety and distributed nationwide. The shot contains killed versions of the three strains, which means it has to closely match the strains that are circulating among the populace.

Some of the most common strains are not always easy to grow, so similar strains are chosen with higher growth rates. But these are often not similar enough. As a result, the efficacy of flu vaccines among the elderly has only been between 30% and 40% over the last few years. Deem's calculations revealed an even lower efficacy rate: between 8% and 20%.

Sometimes there is even negative efficacy. It turns out that a shot one year and not the next may actually increase your risk of getting the flu the following year. This is known in epidemiological circles as original antigenic sin: it's when a vaccination against a disease can actually make you more susceptible. The body's first exposure to an antigen defines the antibody response. The second exposure, to a new antigen, generates a response only to those coat proteins it has in common with the first antigen.

To measure efficacy, researchers examine each strain's hemagglutinin (H) protein, the major protein on the surface of influenza A virus that is recognized by the immune system. In one standard approach, researchers study all the mutations in the entire H protein from one season to the next. In another approach, researchers study the ability of antibodies produced in ferrets to recognize either the vaccine strain or the mutated flu strain, which had been thought to be a good method for predicting flu vaccine efficacy in humans.

However, these approaches are only modestly reliable indications of the vaccine's efficacy. Deem and his Rice University colleagues point out that each H protein has five "epitopes," antibody-triggering regions mutating at different rates. The Rice team refers to the one that mutates the most as the "dominant" epitope Drawing upon theoretical tools originally developed for nuclear and condensed-matter physics–specifically, spin-glass models–the researchers focus on the fraction of amino acids that change in the dominant epitope from one flu season to the next.

Analyzing 35 years of epidemiological efficacy data, the researchers believe that their focus on epitope mutations correlates better with vaccine efficacy than do the traditional approaches. Deem and his colleagues Vishal Gupta and Robert Earl believe that this new measure may prove useful in designing the annual flu vaccine and in interpreting vaccine efficacy studies.

For instance, last year's flu shot included a strain called Wyoming, but Deem's model suggested that a related strain called Kumamoto might have been more effective. Next year's shot will replace Wyoming with an emerging strain called California, a decision his research supports. Deem and his colleagues are hoping to get more recent data from the CDC to further confirm their findings and validate their statistical method.

zero gravity
The Lighter Side of Science

Riordon's Lament

Ed. Note: *The following is based on an incident that occurred late one night, after a hard day's work at the APS March Meeting. A few staff members were sitting around when the subject of the proper spelling of Maxwell's name came up.*

Listen my children and shortly you'll hear
How Jimmy C. Maxwell cost me some beer
It happened the day I decided to bet
On spelling his name, which I now do regret.

I'd heard the name spoken, and, clear as a bell
It sounded exactly like James Clark Maxwell.
"I know how to spell that," I thought, "I'm no jerk,
The name is spelled Clark, and it cannot be Clerk."

But what I forgot was that Maxwell was British,
And spelling in Britain is, at its best, skittish.
I don't take it lightly, but view it quite darkly,
That something spelled Berkeley is verbalized "Barkley".

Driving to Louisville, you can quite sure be
That you will witness the Kentucky Derby.
Driving to Ascot, if you in your car be,
Brings you—surprise!—to a race called the "Darby".

In England the way that they spell is perverse;
In Scotland, if anything, it's even worse.
Jimmy C.'s middle name's spelling is queer,
And that's why I owe everybody a beer.

–Alan Chodos

Researchers Present Wide Variety of New Quantum Tools

Optical antennae, new breakthroughs in cavity QED, and a new twist on three-dimensional diagnostic imaging were among the many technical highlights at the 2005 APS March Meeting in Los Angeles. All three represent valuable new quantum tools for the medical, quantum computing, and quantum communication fields, among other potential applications.

Michael Barnes of the University of Massachusetts-Amherst described the construction of a pair of "nantennae," small posts just 10 nm tall, about 100 million times smaller than a car antenna. The two nantennae interact with each other much like conventional antennae do, as a transmitter/receiver pair. In addition to providing insights into the behavior of light at small distances, the nantennae could be important for photonic-based quantum-information processing applications.

These nanoscale antennae are made with semiconducting polymers, which are already used in LEDs and photovoltaics, for example. Polymers don't normally conduct but they can be made semiconducting if the molecules are properly ordered and aligned. The problem is morphological control: researchers must find a means to impose order on a jumbled mess of polymer molecules. Barnes' team confines single molecules of conjugated polymers in microdroplets on a glass surface and then allows the droplet to evaporate. This can cause the polymers to fold in ways that change their properties so that they become conducting.

Potential applications include quantum computing and tabletop nanoscale photonics, such as phased nantennae arrays and photonic networks, as well as novel light sources for integrated nanoscale optoelectronics. Advantages to be gained from optical antennae include being able to get amplification on a very small scale, such as through linear arrays.

Malvin Teich of Boston University presented a new twist in a 3D diagnostic imaging technique known as optical coherence tomography (OCT), widely used in opthalmology and in creating

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Viewpoint...

Diminished By Discrimination We Scarcely See

By Meg Urry

I came of age when discrimination was a thing of the past, or so I thought. True, there were not many women in my college physics classes, but I figured that was just a matter of time. None of my peers or professors in the early '80s would ever have said out loud, "Women can't do physics as well as men," even though some think it and Harvard University President Larry Summers suggested as much earlier this year.

Still, I can remember a few uncomfortable moments. As a physics grad student, I was one of the few women at professional meetings, and the attention I got from male colleagues wasn't always about science. One professor used to address the graduate quantum mechanics class as "gentlemen and Meg." So I knew that my gender identified me. I just didn't think the distinction amounted to discrimination. It wasn't until a few years ago, after I became a tenured professor at one of the world's top universities, that I finally realized it was discrimination all along.

Discrimination isn't a thunderbolt. It isn't an abrupt slap in the face. It's the slow drumbeat of being underappreciated, feeling uncomfortable and encountering roadblocks along the path to success. These subtle distinctions help make women feel out of place.

I loved MIT as a young astrophysics postdoc there, but back then, it could be a harsh environment for women. (It is vastly improved today.) I remember two professors having a dinner conversation in my presence about the inferiority of women scientists who had been hired because of affirmative action. When I mentioned this to the man who'd hired me, he hastened to assure me that it didn't apply to me. My ambition to be an academic was sometimes met with encouragement, but one male professor told me, "Oh, we would never hire you." Discouragement makes a bigger impression than encouragement.

I started wondering why women weren't getting hired into faculty positions. I'd been told that I'd have no trouble getting ahead: I was a woman, people would come after me. When they didn't, I subliminally absorbed the idea that I wasn't good enough. But was it possible that all the women getting physics and astronomy degrees from top institutions weren't good enough? I saw precious few being hired into faculty jobs.

For some reason, I hung in there. Maybe it was the strong support from my parents and from the fellow physicist I married, who took on half (and sometimes more than half) the responsibilities of child rearing. He doesn't "help" –we share. We made it equal, start to finish. But work was never equal. When I told my thesis adviser I was pregnant, he said, "So, you want to have it all!" I smiled but later thought, Wait a minute, isn't that what all you guys have? Why is it "all" for me and "normal" for you?

Over the years, I saw women in the scientific world treated badly, being marginalized, mistreated, harassed. One woman manager I know was second-guessed, unlike any of the male managers, and when she pointed this out, was told she was depressed and should get professional help. Another told me it had become routine for her to cry while driving home from work. Every woman I know has had her suggestions ignored in a mainly male meeting, only to hear the same idea praised when later raised by a man.

Feeling out of place over and over again eventually soaks in; it did for me. About a decade ago, frustrated and alienated, I approached the director of my institution to ask about special management training for women. Maybe there were tips that would help me navigate the foreign waters in which I found myself. He answered, "Maybe it's not your lack of training, Meg, maybe it's just your difficult personality."

After enough of this kind of thing, women feel beaten down and underappreciated, or worse, they feel incapable. That's the most

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Strained Silicon Could Extend Limits of CMOS Technology

Semiconductor industry leaders are still warning that Moore's Law–the doubling of the amount of transistors on a computer chip every 18 months–is leading the semiconductor industry into an impending crisis as computer chips approach fundamental physical limits. Specifically, higher densities, faster speeds and smaller sizes mean that computer chips will soon be generating more heat as they operate than scientists can remove. But research that physicists started some 20 years ago is coming to the rescue, according to UCLA's Ya-Hong Xie, a featured speaker at the APS March meeting.

Xie is a pioneer in the area of strained silicon–essentially a stretched-out form of silicon –which he believes is an excellent way to make faster, low-power computer chips with conventional CMOS technology. In fact, strained silicon technology is one of the hottest technologies in the IC industry, already appearing in the product lines of major chip manufacturers such as Intel, AMD, Texas Instruments and IBM.

Strained silicon essentially trades off speed with power to address the

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Featured PhysTEC School: University of Arizona

By Ernie Tretkoff

Ed. Note: This is the first in a projected series of articles on PhysTEC schools and their programs.

Photo Credit: Bernard Khoury

Ingrid Novodvorsky addresses a meeting at APS headquarters in 2004.

With a unique science teacher preparation program, the University of Arizona has greatly increased the number of undergraduates training to become physical science teachers. The University of Arizona is also one of the institutions participating in PhysTEC, the APS/AAPT/AIP-led program to improve physics teacher preparation.

The UA science teacher preparation program was established in 1999, when the Dean of the College of Science, disappointed by the low numbers of science teachers produced by the College of Education, hired some new faculty members, one in each of several science departments, who would devote themselves to designing a new program to prepare secondary school teachers in the sub-fields of physics, biology, chemistry, and earth science.

Ingrid Novodvorsky, a physics education researcher and former high school teacher, joined the physics department to direct the science teacher preparation program. The first students began the program in the fall of 2000, and five graduated in 2001. The program now trains about 20 science teachers a year–several times as many as the College of Education was producing before the science teacher prep program began.

The UA science teacher preparation program lets undergraduate science students graduate in their disciplinary majors and simultaneously complete the teacher preparation courses to become eligible for teacher certification. This provides the students a degree of flexibility not common among other teacher preparation programs. In addition, the students graduate with a degree in science, rather than an education degree. "They see themselves as more marketable with a degree in physics," said Novodvorsky.

The students in this unique program take teaching courses that are focused specifically on the subject they plan to teach, rather than a mix of subject areas. This allows for a unique blend of science and pedagogy in the courses. So, for instance, students hoping to become physics teachers might learn about specific technologies that they could use in physics labs, said Novodvorsky. In addition to learning teaching methods, the students in these courses review some science content. "We find that even though they've taken science classes, there are gaps in their understanding," said Novodvorsky.

"Teaching physics is a different kind of skill. You need to know the content and you need to know how to explain it," said Ted Hodapp, APS Director of Education. The UA program is turning out super teachers, he said.

The program promotes various student-centered methods of teaching, but emphasizes using whatever technique is appropriate for a particular topic, said Novodvorsky. The focus is on making sure students learn and understand.

Novodvorsky meets frequently with her counterparts in the other science departments, and although the science teacher preparation program is contained within the College of Science, it retains close ties with the University's College of Education. "It's an interdisciplinary program," said Novodvorsky.

Students in the program are given plenty of opportunity to work with mentor teachers in area middle and high schools. This is an especially important component of the program, said Novodvorsky.

The University of Arizona is one of the original Primary Program Institutions in the PhysTEC collaboration. "PhysTEC came

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VIEWPOINT *from page 5*

insidious thing. After years of being passed over, ignored, and insulted, we start wondering what we are doing wrong. Maybe if I had made the suggestion differently, it would have been heard. Maybe if I lowered my voice and spoke more slowly, I would get more respect. Maybe–even though I published many papers, did seminal work in more than one field, brought in big grants, had successful students and postdocs–maybe I wasn't a good enough scientist.

It was easier to see what was happening to other women than to me. I watched women around me, especially young women, who were smart and keen to work hard, but who, after a few years in grad school or after a discouraging spell as a postdoc, decided maybe they weren't cut out for science, or maybe they would find a non-academic job, or maybe they'd get married and have a family rather than a research career.

I have no problem with any of these choices. What troubles me is that I rarely saw men making them. I think some women use "family" as an excuse to leave science when science actually drives them away. This is a huge loss for our country–These women PhDs are some of the best scientists we train. We need their talent.

In my field, physics and astronomy, women still make up a small percentage of active scientists: about 7 percent of physics faculty are female and about 12 percent of astronomers. Those percentages are increasing, but slowly. So I grew up with almost no women professors. When I first heard of Beatrice Tinsley–who came to the United States in 1964 from New Zealand with a master's in physics, created an entire sub-field of astronomy, finished her thesis under adverse circumstances and by all accounts was an incredible person–I felt the kind of relief that a child raised by wolves must feel when she first sees a human being.

Physics has fewer women than other scientific disciplines. I think it may be because physics is more hierarchical, more aggressive than other areas. ("Combat physics," a friend of mine calls it.) Physicists act as if they are better and smarter than everyone else. The standard for excellence is to be the best in the world–and that seems pretty boastful to polite girls raised not to brag.

When I expressed ambition, though, I sometimes got put back down. I suggested I was ready to be tenured: "Be patient, Meg, it's too early for you." I mentioned I was interested in a high-level national committee: "Isn't that a bit ambitious, Meg?" I expressed interest in a promotion: "You're not a leader, no one would follow you."

Social scientists like Virginia Valian of Hunter College have developed a lot of evidence showing that women and men are treated and evaluated differently. Yet physicists reject the possibility that scientists are not objective. I learned about the lack of objectivity the hard way–through experience.

On hiring committees or tenure and promotion committees I served on, we'd evaluate men and women, and somehow the women seldom came out on top. They were "good," even "very good" but the men were always better. Some of this was caused by letters of recommendation. Every woman was always compared to other women, as if every woman scientist is female first and a scientist second. Also, women's letters were somehow more pedestrian –the candidate "works hard" and she "has a nice personality," "gets along well with others." Once you see the patterns, you realize that these evaluations reflect people's expectations more than reality.

As I got more educated about the abundant social science research, I got more frustrated: The answers were there, if only physicists and astronomers would read the literature. So I made it easier. I organized conferences to talk about these issues. We held that first conference on Women in Astronomy in 1992 and wrote the Baltimore Charter, a kind of manifesto for change (www.stsci.edu/stsci/meetings/WiA/BaltoCharter.html). In 2003 we organized a second meeting, from which the Pasadena Recommendations have just been produced (www.aas.org/cswa/).

It's been slow, but we've made progress, and we're making a difference. More young women are flocking to science every year. It's a great life, after all, doing something you love, having control of your time, being paid pretty well.

And, however slowly, the barriers women face are being abraded. The American Astronomical Society and APS, my professional organizations, have been immensely forward thinking. As for me, Yale hired me with tenure four years ago and treats me wonderfully. My science has never been better. I bet some people say I got this job because I'm female. But now that I've been around awhile, I'm finally able to say, confidently, that I'm really great at this job. I'm lucky to be here at Yale, yes, but even more, they are really lucky to have me. The doubt is finally going away.

Meg Urry is a professor of physics and the director of the Yale Center for Astronomy and Astrophysics. A longer version of this article appeared in the Washington Post, on February 6, 2005. Reprinted with permission.

PhysicsQuest Excites Middle School Classes

In early April, as part of the celebration of the World Year of Physics, five thousand kits, each containing a teacher's guide, a treasure map, and material for four experiments, were mailed to middle school teachers across the country. Their classes will be participating in PhysicsQuest, which, legend has it, was devised by Albert Einstein shortly before his death. The winning class will receive an all-expense-paid trip to Princeton, New Jersey to be present on May 21, when Einstein's treasure will be revealed at a specific time and place.

Discovering what that time and that place are is what PhysicsQuest is all about. The first three experiments pin down the location at which the treasure will appear, and the fourth experiment reveals the time. Students are given a somewhat idealized map of the grounds of the Institute for Advanced Study, where Einstein spent the last 20 years of his career. The first experiment, using a "bubble wand" that enables students to study the shapes of bubbles stretched on a frame, gives them the starting point on the Institute grounds. The second experiment, using a laser and a diffraction grating, will tell the students at what angle (relative to north) they should walk from the starting point on their way to the treasure. The third experiment has them measure the period of a yo-yo (oscillating like a pendulum), thereby determining the pendulum's length and hence the distance they have to walk to get to the location of the treasure.

The fourth experiment asks the students to study the patterns of iron filings produced by arranging a pair of bar magnets in different configurations. They must match a given pattern to determine the time at which the treasure will appear. The winning class will be selected in a random drawing from all the correct answers received by the April 22 deadline, and will be announced in the June *APS News*. The July *APS News* will contain a report on the events at the Institute on May 21 that will bring PhysicsQuest to its dramatic conclusion.

More about PhysicsQuest can be found on the World Year of Physics web site at www.physics2005.org . In particular, there is a link to the web version of the PhysicsQuest video, that is being distributed in CD format along with the kits.

CMOS TECH *from page 5*

heat problem. By stretching a thin layer of silicon, two of its six electrons drop to a lower energy level, so it can achieve the same amount of conductance at lower power. However, to be effective, the sample material must be perfectly homogenous. Xie uses epitaxy to grow his materials layer by layer. He starts with a layer of silicon germanium (SiGe) layer. The top layer "relaxes" and a silicon layer is grown on top of that. This second layer has a large lattice constant–that is, it is "strained"–because the new layer tends to take on the structure of the layer immediately beneath it.

Also at the meeting, George Celler, chief scientist at the semiconductor manufacturer SOITEC described silicon-on-insulator (SOI) technology as another solution for making faster chips. SOI has raw speed, up to 30% faster than bulk silicon, a gain of an entire chip generation. It also consumes less power and has lower heat so the chips don't melt. And it can incorporate strained silicon technology.

Thus, SOI may be the key to faster, cooler chips, reducing heat for the same amount of power. Celler predicts a billion dollar SOI market by 2008. There are many fabrication facilities for SOI currently under construction around the world, and the next generation of game machines–Sony's Playstation 3 and Xbox Next from Microsoft–will use SOI substrates.

Ralph Cavin, president of SemaTech, said that the IC industry expects to reach the technological limits of silicon by 2015-2018, when the dimensions of transistor gates are only seven times smaller than they are today. There is a great deal of research and development focused on new technologies: spintronics, molecular electronics, and further out, quantum computing. But he also insisted that silicon isn't going anywhere: CMOS is a $200 billion per year market.

ZEPTOGRAM *from page 1*

silicon carbide beam, about a micron long and about 100 nm wide. The beam is clamped at both ends, and set oscillating at over 100MHz.

To introduce the molecules or atoms to be weighed, the researchers open a shutter, allowing a brief spray of molecules–in this case a gas of xenon atoms or nitrogen molecules–to enter the chamber and condense onto the oscillating bar. The added mass lowers the beam's resonant frequency by a precise amount, which the sensitive electronic circuitry detects, allowing the researchers to determine the weight of the added molecules. The device is currently sensitive to a few zeptograms.

Several years ago the Caltech research group achieved attogram (10^{-18} g) sensitivity with a similar, slightly larger, device made of silicon instead of silicon carbide. The new device works in essentially the same way as the previous version, but its smaller size and higher resonant frequency gives it a greater sensitively to added mass. The group hopes they can improve the design further to achieve sensitivity in the yoctogram (10^{-24} g) range–about the mass of a single hydrogen atom.

With the current zeptogram sensitivity the technique can detect a single protein molecule, but in order to distinguish between different proteins with similar masses, yoctogram-level sensitivity would be necessary, said Roukes. The goal of single biological molecule mass sensing is actually within reach, he said. "We believe we have the tools to do this."

The technology could eventually lead to the creation of microchips containing arrays of miniature mass spectrometers, which would be much cheaper and more convenient than the huge conventional mass spectrometers now in use in proteomics laboratories.

If they can improve the technology to achieve yoctogram sensitivity, the system could be used to detect the individual proteins secreted by cancer cells. "We hope to transform this chip-based technology into systems that are useful for picking out and identifying specific molecules one by one–for example, certain types of proteins secreted in the very early stages of cancer," said Roukes.

QUANTUM TOOLS *from page 5*

cross-section images of biological tissue for noninvasive optical biopsy. By replacing the broadband light source used in traditional OCT with pairs of entangled photons, the BU researchers have performed demonstrations of "quantum optical coherence tomography" (QOCT)–imaging the surfaces of fused silica windows while increasing the axial resolution of the resulting images by a factor of five.

The investigators produce photon pairs by passing laser light through a nonlinear optical crystal, in this case a krypton-ion laser beam directed at a crystal made of lithium iodate. The twin photons that emerge continue to be linked even as they are directed along different paths: one toward the sample under investigation, the other toward a mirror.

Both ultimately reach photon detectors. Observing a signal in both detectors requires that the path lengths of the two photons be the same. Changing the mirror's position changes the depth from which a reflection is observed, so the image of the sample's interior is much more accurate.

Teich plans to test these technologies on biological samples such as salamander retinas. The salamander retina has a layered structure so it is not smooth, and there is more scattering of light. Teich wants to know how this extra scattering will affect the technologies' resolution. Potential applications include learning more about the structure of the retina and its many layers; dermatological imaging (such as skin tumors); and small devices inserted into a catheter to look for plaque in vivo in blood vessels.

Jeff Kimble of Caltech presented his group's latest experimental breakthroughs in cavity QED, in which a single atom is trapped in an optical resonator formed by two mirrors separated by 40 microns. Such a setup is a promising building block for quantum computation and communication, since the energy levels of the atom could constitute a useful "quantum bit" and the atom-field interaction can enable quantum logic operations between pairs of atoms or photons.

Kimble's group has demonstrated what he considers the first "quantum protocol" for cavity QED, and also discovered a "photon blockade" for light traveling through the cavity. Trap one atom in a small cavity and then add photons. The atom should absorb and emit, absorb and emit, achieving some form of coherence. By this means the cavity can emit photons without the atoms going into an excited state. The flaw is it's difficult to control, so sometimes more than one atom end up in the cavity. This single photon generation is both coherent and reversible. Kimble hopes to use this technology to build a simple quantum optical network.

FUEL CELL *from page 2*

On the macroscale, when two streams come together, turbulence causes them to mix, such as when two rivers merge or you pour cream into your coffee, Kenis explained. But on the microscale, fluids can flow without turbulence, so several thin streams can flow down the same narrow channel without mixing, creating an arrangement that looks like Aquafresh toothpaste, said Kenis.

Kenis and his colleagues took advantage of this laminar flow to design a more efficient fuel cell. A typical fuel cell consists of two electrodes, a fuel source, an oxidant, and a membrane separating the fuel and oxidant. Reactions at the anode strip protons and electrons from hydrogen atoms in the fuel. The protons pass through the membrane to the cathode, where they combine with oxygen gas to form water, while the electrons travel through an external circuit, providing current to an electronic device. Most fuel cells now use a polymer electrolyte membrane to separate the fuel and the oxidant.

The new fuel cell design does away with the membrane. Instead, it consists of a Y-shaped channel in which two tiny liquid streams, one fuel and one oxidant, merge and continue to flow in parallel without mixing in a millimeter-wide channel between two catalyst-covered electrodes.

This configuration has few parts and a simple, elegant design, said Kenis. His said his group's tests indicate that the novel device could perform better than the standard membrane-based fuel cells, which have several significant problems. For instance, the membrane tends to be a very expensive component. Membranes can sometimes allow fuel to cross over to the wrong side, degrading the performance of the cell.

Also, although alkaline fuel cells would outperform acidic ones, membrane-based fuel cells don't work well with alkaline chemistry, for several reasons. Most membranes, which permit protons to pass in acidic fuel cells, are not permeable to the larger hydroxide ions which would, in an alkaline cell, take the place of the protons. Also, alkaline reactions produce carbonates, which tend to clog the membrane. But in the new microfluidic fuel cell, hydroxide ions can freely diffuse through the boundary between the fuel and oxidant, and the steady flow just washes the carbonates away, so they don't clog the device.

(Actually, alkaline fuel cells with membranes are used by the space program, but they require exceptionally pure hydrogen as the fuel to avoid clogging the membrane, and so they are prohibitively expensive for commercial applications, said Kenis.)

The new fuel cell is small to take advantage of microfluidic properties, and could not simply be scaled up to make larger fuel cells. "Since the membraneless fuel cell is based on a phenomenon that only occurs at the microscale, we can't just scale up to larger dimensions," said Kenis. However, many of the tiny fuel cells could be linked together into arrays to produce more power.

ANNOUNCEMENT

Distinguished Traveling Lecturer Program in Laser Science

The Division of Laser Sciences (DLS) of the American Physical Society announces the expansion of its lecture program in Laser Science, and invites applications from schools to host a lecturer in 2005. Lecturers will visit selected academic institutions for two days, during which time they will give a public lecture open to the entire academic community and meet informally with students and faculty. They may also give guest lectures in classes related to Laser Science. The purpose of the program is to bring distinguished scientists to colleges and universities in order to convey the excitement of Laser Science to undergraduate and graduate students.

The DLS will cover the travel expenses and honorarium of the lecturer.

The host institution will be responsible only for the local expenses of the lecturer and for advertising the public lecture. Awards to host institutions will be made by the selection committee after consulting with the lecturers. Priority will be given to those institutions that do not have extensive resources for similar programs.

Applications should be sent to the DTL committee Chair Rainer Grobe (grobe@ilstu.edu) and to the DLS Secretary-Treasurer Dan Elliott (elliottd@ecn.purdue.edu). The deadline for application for visits in Fall 2005 is April 30.

Detailed information about the program and the application procedure is available on the DLS-DTL home page: http://physics.sdsu.edu/~anderson/DTL/

Lecturers for the 2005-2006 Academic Year

Robert Byer, Stanford University.
Lee W. Casperson, University of North Carolina.
Jim Kafka, Spectra Physics.
Marsha Lester, University of Pennsylvania.
Christopher Monroe, University of Michigan.
Luis A. Orozco, University of Maryland.
Carlos Stroud, University of Rochester.
Ron Walsworth, Harvard University.

TSUNAMI *from page 1*

Association (RUSTA), the RUSTA Relief Fund. The fund was established to assist 24 students who need the most immediate help.

"Most of these students lost their parents and properties, including their houses," explained Samarasekara. He provided APS with a report on the damages, letters from his university's officials, and descriptions of each student's losses.

Donations to the RUSTA Relief Fund will provide monthly assistance to these students for books, food, and clothing during their university careers. Samarasekara offered to give APS the details of these students every month until they graduate from the university. "While the APS does not wish to impose upon the university to deliver monthly reports, we are emphatically calling upon APS members to donate to this fund," said Flatten.

APS will send a lump sum contribution after donations are received during the month of May. To contribute to the scholarship fund to help the Sri Lankan students, click on "Tsunami Assistance Donations"on the APS home page (www.aps.org).

PHYSTEC *from page 6*

about a year after we started our program. That collaboration has been a really nice fit with what we were already doing," said Novodvorsky.

PhysTEC provides the funding for the UA physics department's "teacher-in-residence," a teacher from a local school who mentors the students and recent graduates, and works with the department on revising courses. "The teacher-in-residence provides a kind of reality check, and they carry a lot of weight with the students. It does make a difference," said Novodvorsky.

Hodapp also emphasizes the value of the teacher-in-residence. New teachers who have good mentors are more likely to stick with teaching, he said. "PhysTEC identifies mentoring as critical," said Hodapp.

Within the UA physics department, there is a lot of respect and support for the science teacher preparation program, said Novodvorsky. The department realizes that training teachers is part of their mission, and they encourage students with any interest in teaching to consider the teacher prep program. In fact, when the program started, Novodvorsky thought she would have difficulty recruiting students, but it has turned out that the program has as many students as it can handle.

The Back Page

Einstein, Ethics and the Atomic Bomb

By Patricia Rife

Albert Einstein was morally opposed to war throughout his life, and this ethical stance had deep roots in his childhood education. Raised in Munich until the age of 12, young Albert was schooled in both the required Catholic and supplementary Jewish religious education classes. His sister, Maja, recalls that her brother "heard about divine will and works pleasing to God–without those teachings having been integrated into a specific dogma…. Later these feelings gave way to philosophic thought, but absolutely strict loyalty to conscience remained his guiding principle."

Their father, known for his sunny, optimistic temperament, brought a poor Jewish medical student, Max Talmud, from Poland, to their home many times for meals. The scholar-scientist had a profound influence on the boy. Talmud introduced him to the philosophy of Kant, popular books on the physical sciences, and debates about science and mathematics then raging in Munich. Einstein recalled this seminal influence in his autobiography:

Through the reading of popular scientific books, I soon reached the conviction that much of the stories in the Bible could not be true. The consequence was a positively fantastic "free thinking" coupled with the impression that youth is intentionally being deceived by the state through lies; it was a crushing impression. Suspicion against every kind of authority grew out of this experience, a skeptical attitude towards the convictions which were alive in any specific social environment – an attitude which has never again left me….

After his seminal works on relativity, a divorce, and a job offer to relocate to Berlin, Einstein's world –and the focus of his life work– shifted. He moved to the northern Prussia capital during 1907-1908, along with many other physicists who had been invited there by Max Planck. These included Planck's then-assistant, Max von Laue; the shy Lise Meitner from Vienna; Wilhelm Hertz; and Hans Geiger.

In 1912, Einstein declared himself to be a "citizen of the world," a few years before the onset of "the war to end all wars." He refused to participate in any military activities. Meanwhile, the universities were drained of their scientific staff, students, and professors as they joined the Army or undertook military research. Gas warfare became the focus of chemists in Berlin, and the Kaiser-Wilhelm Institute for Chemistry was turned over to the military. But none of the patriotic rhetoric or nationalist fervor impressed Einstein. He remained a declared pacifist during World War I.

Einstein's troubles with militaristic German scientists began as early as 1923, when the right-wing nationalistic physicist Johannes Stark began attacking the theory of relativity as "Jewish propaganda physics." Other World War I veterans were lauded for their "practical" utilitarian approach, while Einstein's work was smeared as "impractical theory" by young Brown Shirts in the growing Nazi Party. Einstein's fame had catapulted him into the global spotlight: he was filmed with Charlie Chaplin in California; he and his second wife, Elsa, visited Japan and cordially drank tea with the Emperor; avant-garde painters and musicians flocked to Berlin to ride the tide of the "Roaring Twenties," and even painted portraits of the "theoretical dreamer."

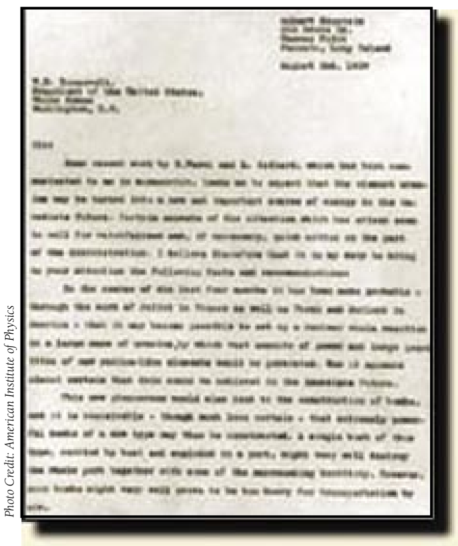
Photo Credit: American Institute of Physics

Einstein's Letter to Roosevelt

Einstein remained aloof from all this "social relativity" talk. He was dedicated to science, not advancing modern culture, he modestly affirmed. He cultivated a conservatism concerning quantum mechanics, debating long into the night with Niels Bohr about quantum physics and philosophy. Little did Einstein realize that the Nazi splinter groups would manipulate his fame as a Jewish scientist – and later, publicly burn his books –as a target for their vicious anti-Semitism.

Foreboding signs were apparent after the worldwide stock market crash of 1929, and throughout Germany, hungry dissatisfied workers, strikes by communist party and socialist movements, and the rise of Hitler's diatribes against "outsiders" made the dreamy-looking Jewish physicist an easy target for the irrational hate and anti-Semitic propaganda.

In January 1933, while Einstein was on a lecture tour in sunny Pasadena, California, the Reichstag fire took place. Adolf Hitler was elected Chancellor and approved by President Kaiser Wilhelm to lead the Third Reich. Einstein held a press conference in California and spoke out strongly against Hitler, considering it his social responsibility to do so. Soon, the tragedy that had occurred in the universities was known around the world. Professors were fired, disappeared, or lost all of their rights and pensions–and not just Jewish physicists. Others, such as James Franck, resigned in vocal protest. Einstein's house was padlocked and his savings account confiscated in 1933, under the pretense of the Gestapo searching his belongings for "anti-government literature." (Fortunately he was still on tour in California at the time.) Many intellectuals who disagreed with the Third Reich had been arrested or sent to concentration camps.

Ironically, during this same period of time, Einstein found himself also defending his views on science and religion in America from attacks by theologians and rabbis, who sought to refute his "deterministic causality." Some even called him an atheist since his views of God did not match their own. However, Einstein stated – and published–again and again that he did not refute the wonder of God, but only the "naïve beliefs" of people who thought of a God who "punishes" based on fear. Hence, his ethics based on his spiritual beliefs, formed the basis of his stance on social responsibility.

Before Hitler's army brutally invaded Austria and Czechoslovakia in the Anschluss of 1938, many did not view the internal purges of German industry, research centers, universities and other organizations as "fighting." Rather, the Gestapo were viewed as an elite police force "enforcing the law," not an extension of the Army. Yet Einstein continued to speak out bravely against all aggression from his humble new home provided by Princeton University. He wrote to many of his colleagues, challenging them to stand up for their moral beliefs, but many stood up for the Fatherland instead, including Max Planck, who was then president of the German Academy of Sciences. Einstein never truly forgave his aging mentor, as swastikas were unfurled over the esteemed Akademie and other German research institutes.

The discovery of fission in 1938 was so startling that when Hahn and Strassmann–and soon Lise Meitner and her nephew Otto Frisch,–published their interpretations of the "splitting" of the uranium nucleus, reporters leapt to their phones when the news was announced in America. Meitner and Frisch proved experimentally that fission did release an enormous amount of energy (based on Einstein's $E=mc^2$). When Frisch notified his mentor, Niels Bohr, Bohr cancelled his planned visit with Einstein in the winter of 1939 in exchange for debates and publishing on the mechanism for fission. This news electrified scientists worldwide, but soon it became compartmentalized, and would be applied via the secret of governments, not research labs. Einstein was not privy to these government research labs throughout World War II and never worked on any weapons research.

Exiled in America during the 1930s, faced with the death of his wife, Elsa, in 1936, and cared for only by his stepdaughter and quiet secretary, Einstein took a vacation in the summer of 1939 to Long Island, New York, as the winds of war increased in Europe. There he was approached by "the younger generation," physicists Leo Szilard and Eugene Wigner, who were very fearful about Hitler's potential for developing atomic weapons. They feared that uranium in the Belgium-controlled Congo would be confiscated by the Nazis. They also feared that brilliant physicists such as Werner von Braun, or Heisenberg, would create a chain reaction which the Third Reich would harness for "weapons of mass destruction," to borrow the modern terminology. Szilard had worked through the calculations for a chain reaction and presented this to Einstein.

Einstein's famous August 2, 1939, letter to then-President Roosevelt was drafted by Szilard. In it, Einstein concisely described the "potentially dangerous situation" to the US government. German scientists were apparently at work on the applications of nuclear fission, Einstein warned in his letter, which was delivered by a diplomatic friend. "Certain aspects of the situation [regarding nuclear energy] seem to call for watchfulness and, if necessary, quick action on the part of the Administration," he wrote, adding, "This new phenomenon would also lead to the construction of bombs, and it is conceivable–though much less certain–that extremely powerful bombs of a new type may thus be constructed." The letter certainly influenced the President's decision to create the Manhattan Project in 1940.

Fifteen years later, Einstein still regretted his actions. "If I had known that these fears [of the Germans developing an atomic bomb first] were groundless, I would not have taken part in opening that Pandora's box," he wrote to Max von Laue, in 1955. Yet others were adamant that the Truman administration's decision to drop atomic bombs over Japan did save countless lives, in order that the war would not drag on for more months or years.

Einstein was not a diplomat. Yet when the war ended, physicists were in the spotlight. He was famous not just for the theory of relativity and winning the Nobel Prize, but for his own gentle "public trust and image." Szilard decided to create a truly peace-oriented organization that could leverage Einstein's fame while also building an international platform for co-operation, as well as dialogue, between physicists. Einstein agreed to become the first chairman of this Emergency Committee of Atomic Scientists in 1946. Members such as Linus Pauling, Hans Bethe, Victor Weisskopf and others became Trustees and met regularly at Princeton and in New York City.

It took a concerted effort for the Trustees and staff of the fledgling Committee to agree on their platform and mission, but they all agreed that a journal should be created (later called *The Bulletin of Atomic Scientists*) and an educational campaign conducted throughout America concerning the dangers of atomic weapons. With Einstein as their spokesman, their message of "the unleashed power of the atom" had a trusted public figurehead.

Many scientists decided to continue to leverage their own international visibility to turn the tide of public opinion towards peace. Lise Meitner was invited by the US Women's Press Club to dine in the White House. Szilard drafted a bold letter to Stalin in Russia, challenging him to join international cooperation efforts on atomic weapons. Einstein agreed in principle. This letter set off a wave of backlash when it was published in the Bulletin in 1949, even though it was never sent to Stalin. The gauntlet was laid down. The US government held one position about maintaining secrecy around atomic and nuclear weapons research, while many scientists friendly to Einstein favored international cooperation, and even proposed that "world government" agencies, and not America, should deal with issues of war and peace in a nuclear era. Controversial or not, Einstein strongly supported these platforms.

There were no simple answers to the complex questions surrounding atomic weapons in the post-war world. Listen to the prophetic words of Einstein, spoken at a one-day conference at the Institute for Advanced Study on November 17, 1946:

To have security against atomic bombs and against the other biological weapons, we have to prevent war, for if we cannot prevent war, every nation will use every means that is at their disposal; and in spite of all promises they make, they will do it. At the same time, so long as war is not prevented, all the governments of the nations have to prepare for war, and if you have to prepare for war, then you are in a state whewre you cannot abolish war.

These words still ring true today, 59 years later. Will a new generation hear them and rise to our own social responsibilities? In my opinion, world peace is worth the effort, and like Einstein – who declared himself a citizen of the world and worked for world peace all his long, eventful life—I continue to work for this ethical stance.

Patricia Rife is on the faculty of the Graduate School of Technology and Management at the University of Maryland's University College. This article is based on a talk she gave at the 2005 APS March Meeting in Los Angeles.